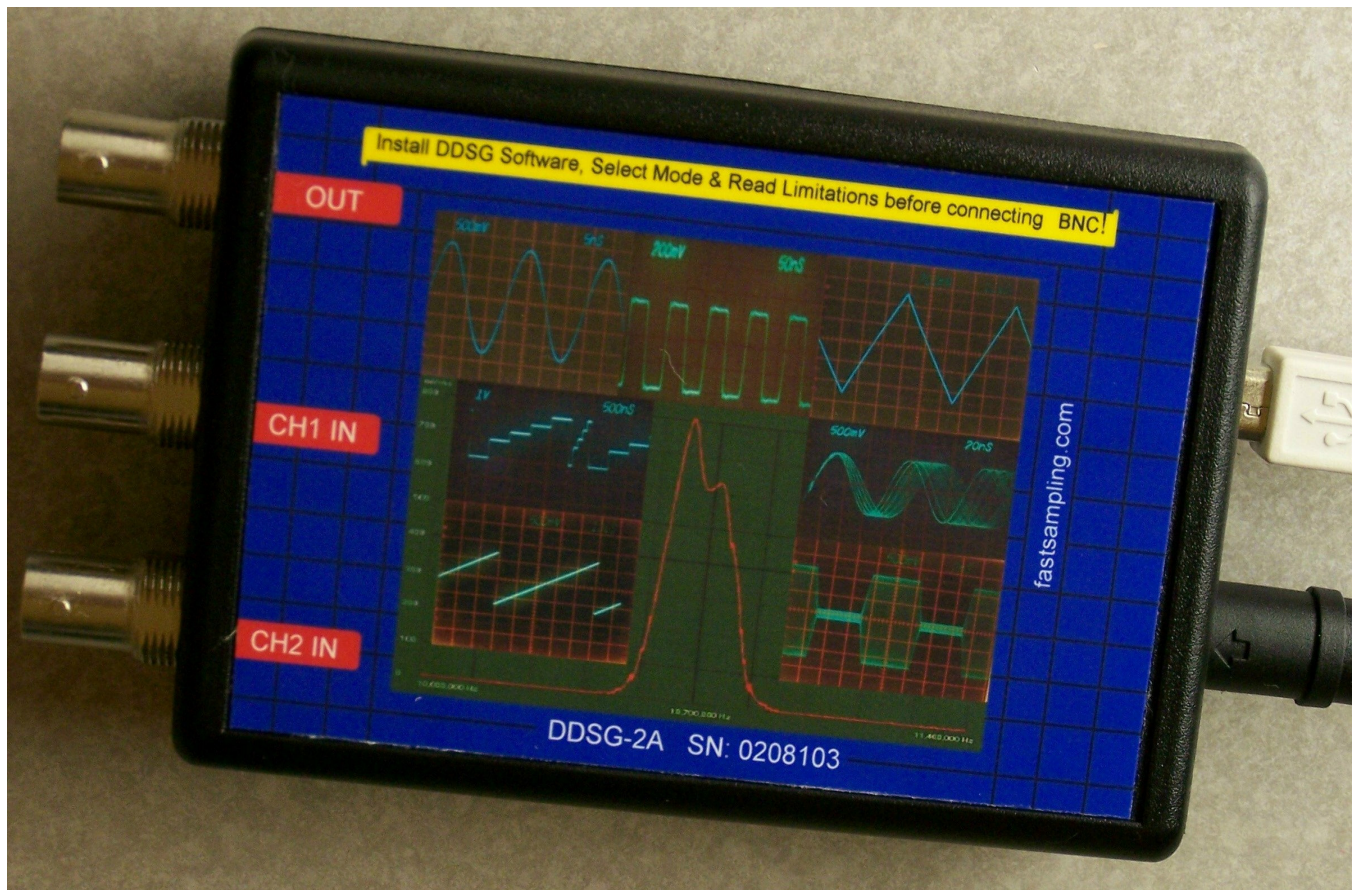


# USB Function Generator / 2-Channel Oscilloscope / Frequency Counter



## DDSG2A User Manual

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## **Introduction**

The DDSG-2A is a multi-function electronics test and measurement device comprising a Direct Digital Synthesizing (DDS) Function Generator, a 2 channel Real-Time Storage oscilloscope (DSO) Demodulating Logarithmic Amplifier (log amp), and a Frequency Counter. In addition, the DDS, Log Amplifier and DSO functionality is combined to allow integrated frequency/amplitude sweep generation and response monitoring for easy characterization of frequency response of circuit under test.

The small, portable hardware package connects to your PC via an optically isolated full speed USB interface for PC protection and eliminates effects of noise from USB bus and PC ground.

All device control and monitoring is managed via an intuitive graphical PC software interface. The use of small package fine pitch components allows high number of functions to be integrated in a small and economical instrument.

This low- cost, easy to use device is a perfect solution for engineers and hobbyists alike who need to generate and analyze signals from DC to 100 MHz

Unit is capable to generate signals to 200 MHz but with increased distortion caused by DDS maximum clock is limited to 400 MS/s.

Light weight plastic enclosure contains one layer of aluminum folium from inside to improve device immunity to EMC and minimizes interference with other electronics device.

PCB assembly is done using automated pick and place machine with vision system.

Re-flow profile is computer controlled and after testing board is coated with urethane.

## **Arbitrary Function Generator with Direct Digital Synthesizer (DDS)**

The Direct Digital Synthesis Function Generator provides an array of standard signal waveforms, including; Sine, Square, Ramp, Triangle & Pulse. Additionally, more complex waveform are provided, such as, Swept Frequency Sine, Modulated Sine Wave (AM/FM) and Arbitrary Waveform Generation (Voltage, Frequency, Phase). Finally Swept Sine Frequency or amplitude modes are provided, integrated with the DSO monitor, for analysis of frequency and amplitude response characteristics of system under test.

TXCO Frequency stability is 2.5ppm.

### **Generator Operating Modes:**

- Single Tone- Sine, Square, Ramp @ Triangle
- Pulse (user specified mark/space)
- Swept sine (Freq start/stop and step period control)
- AM/FM modulated Sine (external Modulation)
- Arbitrary (Voltage, Frequency, Phase)

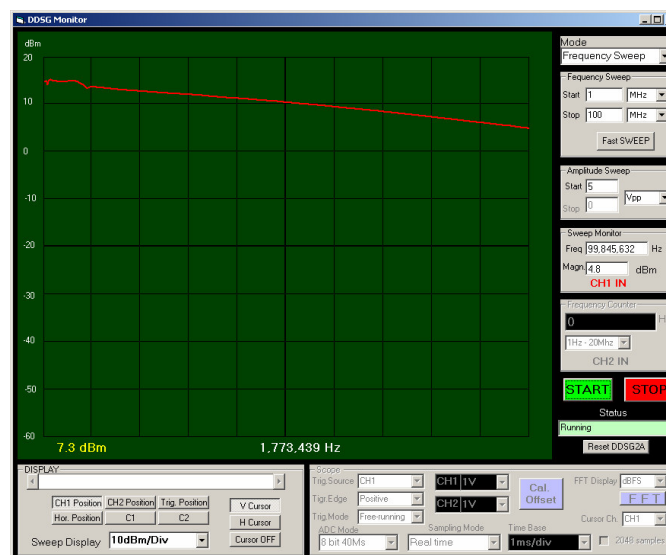
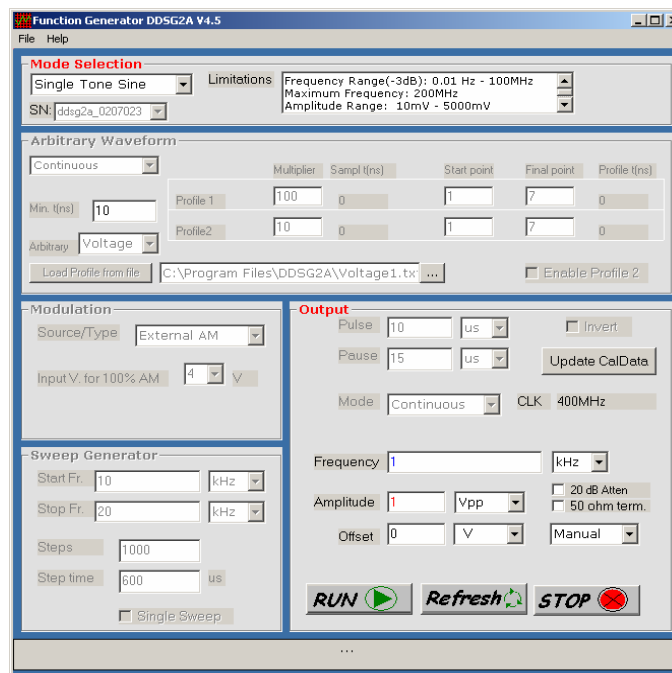
- Frequency and amplitude sweep with monitor(mVrms, dBmV or dBm)

The Function generator is controlled through the easy to use PC based Graphical interface shown right.

Mode Selection activates all the appropriate control panels for clarity and also conveniently displays signals limits of selected mode in same window.

As well as the generator modes controlled by this application, the monitored frequency and amplitude sweep functions are controlled in the “DDSG Monitor” window shown below

Maximum available power into 50 ohm load from 1 to 100 MHz



## Generator Specification

Parameter	Min	Max	Typical	Description Comments
Time Base Accuracy			$\pm 2.5\text{ppm}$	Derived From TCXO Data Sheet
Frequency range Sine Wave	0.01 Hz	100 MHz		Increase distortion and No amplitude calibration for frequencies 100 -200Mhz due to max DDS DAC sample clock of 400MS/S
Frequency resolution Sine wave and square wave mode			0.00465Hz with 20Mhz clock 0.093 with 400Mhz clock	
Amplitude range	10mVpp High-Z 5Mv-50Ohm	5Vpp @DC- 40Mhz@High-Z 2.5Vpp -50Ohm		See page# 2 for available power into 50 Ohm over frequency range
DC Offset	-1V	4V		No load or hi Impedance load(divide by 2 for 50ohm load)
Output impedance			50 Ohm	
Pulse width	10ns	2s		
Rump and Triangle Frequency range	0.1 Hz	100KHz		
Arbitrary points	2	1024		
Arbitrary points sampling frequency	250 Hz	100Mhz		
DDS Clock Range	1 MHz	400 MHz		

Parameter	Min	Max	Typical	Description Comments
DDS DAC Voltage Resolution			14 bit	Derived From DDS IC(AD9954) Data Sheet
DDS Phase Control Resolution			14 bit	Derived From DDS IC Data Sheet
DDS Frequency resolution			32 bit	Derived From DDS IC Data Sheet
DDS Amplitude (scale)Control Resolution			14 bit	Derived From DDS IC Data Sheet
DDS Phase Noise			105 dBc/Hz	Derived From DDS IC Data Sheet
Rise/Fall time(square wave and pulse)			5ns	

### **Using Generator**

Power and USB cables have to be connected before DDSG2A application is open. Two separate windows should appear after DDSG2A is open.

One window is called “Function GeneratorDDSG2A” and second one is “DDSG Monitor”.

Generator window contains controls for signal generated only and monitor contains controls for Oscilloscope, Frequency Counter and also controls generator in Frequency Sweep mode.

If DDSG2A device is used only as generator then monitor window can be closed or downsized, but monitor window can not work alone with generator window closed.

## **Generating Single tone sine and Modulated sine**

1. Connect Generators “OUT” to circuit under test
2. Open “Function Generator DDSG2A” window
3. Select “Single Tone Sine” or ”Sine Modulated” (if modulation needed) in “Mode Selection” combo box
4. Select frequency unit (Hz, kHz or MHz) in combo box right from frequency entry text box
5. Enter frequency value in frequency text box
6. Select amplitude unit in combo box
7. Enter Amplitude value
8. Select DC Offset mode (Manual, Vpp/2 or 0.00); if manual mode is selected then offset unit have to selected and offset value have to be entered. If Vpp/2 is selected then device will generate offset equal Vpp/2 so that output voltage is always positive only swinging from 0 to Vpp. Use “Vpp/2 “ to drive TTL or CMOS digital circuit .
9. Check 50 Ohm box if circuit under test have input impedance of 50 ohm
10. Check 20dB attenuator for low amplitude low noise signals.(0-500mV or 0-250 mV@50ohm)
11. If “Sine Modulated” mode is selected then perform following four steps:
  - Connect modulation signal to CH1 input of Function Generator and use volt/div channel one to adjust amplitude since modulation signal use scope channel 1 amplifier
  - Select modulation type (External AM or External FM)
  - If “FM” is selected then maximum frequency deviation will be about 100 KHz for 4Vpp Input signal (use arbitrary frequency mode for greater deviation)
  - Select additional AM modulation gain (0.5,1,2 or 4 Volt of input voltage to make 100% AM
12. Click “RUN” or “REFRESH”

Output signal should be present at” OUT” If all entries are within device operating range.

If entered amplitude is higher then available power at given frequency then message box saying that amplitude is to hi for frequency entered and device will generate maximum available power after clicking ok on message box.

Read “calibration” section, if output amplitude, offset or frequencies errors are in not acceptable range.

## **Generating Pulse**

1. Connect Generators “OUT” to circuit under test
2. Open Function Generator window
3. Select “Pulse Generator” in “Mode Selection” combo box
4. Select “Pulse” and “Pause” duration unit (ns, us or ms)
5. Enter “Pulse” and “Pause” duration value
6. Select “Single” or “Continues” in “Mode” selection box
7. Select amplitude unit in combo box
8. Enter Amplitude value
9. Select DC Offset mode (Manual, VPP/2 or 0.00); if manual mode is selected then offset unit have to selected and offset value have to be entered. If Vpp/2 is selected then device will generate offset equal Vpp/2 so that output voltage is always positive only swinging from 0 to Vpp.
10. Check 50 Ohm box if circuit under test have input impedance of 50 ohm
11. Check 20dB attenuator for low amplitude low noise signals.(0-500Mv or 0-250 Mv@50ohm)
12. Click “RUN” or “REFRESH”

If “Single” mode is selected then single pulse will be triggered with click on” RUN”

Software will use best hardware ability to generated pulse as close as possible to value entered.

Pause duration will have greater error since pause time is made using smaller time segments which duration will depend from pulse length.

Use invert check box for negative pulse polarity.

## **Generating Arbitrary Voltage**

See “Voltage1” text file found in DDSG2A installation folder for reference.

1. Make tab separated arbitrary points text file like one with first five points in example file supplied (Voltage1.txt) with DDSG2A software. First two lines will be ignore by application and can contain anything. Third line contains first arbitrary point. Voltage value must be in second column and range is from 0 to 5000Mv.
2. Connect Generators “OUT” to circuit under test



3. Open Function Generator window
4. Select “Arbitrary” in “Mode Selection” combo box
5. Select “Voltage” in “Arbitrary” combo box
6. Enter minimum time step “Min.t(ns)” (range is 10-66ns)
7. Enter multiplier value for profile1 and profile 2 if profile2 is used.(one arbitrary point  
**period = “Min.t(ns)” \* multiplier**)
8. Enter profiles start and stop point number
9. Load arbitrary file using browser button and “Load profile from file” button
10. Click “REFRESH” or “RUN” Button.

#### Example of arbitrary file with 2 profiles

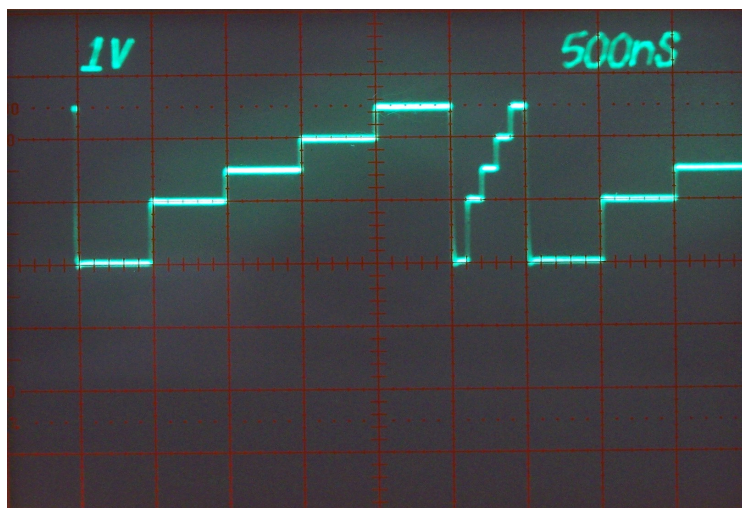
One profile have multiplier of 50 and second of 10, which with minimum time step of 10ns and start point=1, Final point = 5, generates form shown on picture below.

Arbitrary voltage file contains:

Arb.Pt.     Voltage (mV)

-----

1	0
2	1000
3	1500
4	2000
5	2500



### Generating Arbitrary Frequency

Follow same steps as described in “generating arbitrary voltage” section, except that arbitrary file will contain frequency values in hertz and arbitrary selection will be frequency.  
See “Frequency1” text file found in DDSG2A installation folder for reference.

### Generating Arbitrary Phase

Follow same steps as described in “generating arbitrary voltage” section, except that arbitrary file will contain Phase values in degrees (0.00-360.00) and arbitrary selection will be Phase.

See “Phase1” text file found in DDSG2A installation folder for reference.

### **Generating Sweep Sine**

1. Select Sweep Sine generator in “Mode Selection”
2. Enter start frequency, stop frequency, number of steps and step time in sweep generator frame.
3. Select amplitude and dc offset following steps described in “generating single sine”
4. Click “RUN” or “REFRESH”

### **Generating Square Wave**

Wave can operate in two different modes.

In “Square Wave” mode DDS uses RAM and arbitrary voltage feature to generate square wave. Amplitude resolution in this mode is 14 bit and frequency resolution error is maximum 50 kHz. Bias and amplitude range is same as in single tone sine.

In “Square Wave2” mode DDS generate sine wave first then use comparator then a programmable attenuator before final amplifier.

Amplitude resolution is 8 bit and output range is:1-5 Vpp

Frequency resolution is 0.1 Hz

There is no bias control.

Amplitude in this mode is sensitive on temperature change since it uses active attenuator for amplitude control.

This mode is mainly provided to be used for logical gates driving and to be used with under sampling DDSG2A scope function to measure propagation delay since frequency and phase can be controlled allowing DDSG2A scope to display signal with bandwidth of 100MHz.

See calibration section for amplitude calibration in “Square Wave2” mode.

### **Frequency Sweep with RF Monitor**

The DDS AND DSO functionality of DDSG2A have been combined to allow integrated frequency/amplitude sweep generation and response monitoring for easy characterization of the

frequency & amplitude response of system under test.

The measurement and display functions of the monitor are closely coordinated with selected sweep signals and sweep signal control and monitoring is also combined in “DDSG2A” Monitor for user convenience.

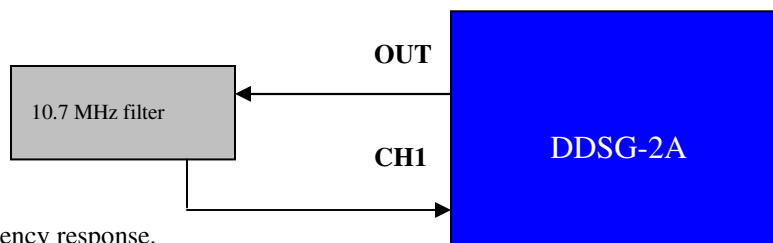
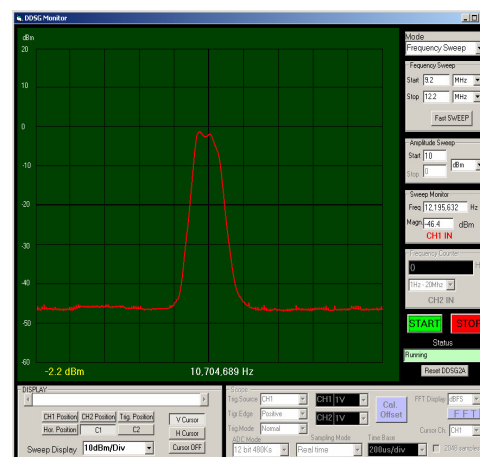
The display can be configured for a variety of vertical measurements units (mVrms, dBmV, dBm).

The example below illustrates the frequency sweep function used for characterization of a 10.7 MHz band –pass filter.

Monitor sweep specifications:

- Voltage detector amplitude range -77-0Dbv
- Detector frequency range 200khz-200Mhz
- Input impedance 50 ohm
- Monitor amplitude measurements: 100mVrms/div, 250mVrms/div, 5dBmV/div, 10dBV,10dBm, 15dBm

1. Select “frequency sweep” mode in DDSG Monitor Window (Shown on picture right)
2. Enter start and stop frequency
3. select amplitude unit and enter amplitude
4. Select RF detector display unit (left lower corner of window (100mVrms/div, 250mVrms/div,10dBm..etc)
5. Connect DDSG2A device “OUT” to the input of circuit under test.
6. connect ddsg2a CH1 IN to circuit under test output
7. Click START



This test shows band pass filter frequency response.

Start frequency is set to 9.7 MHz and stop frequency to 11.7Mhz

Generator output amplitude is 0dBm

## **Amplitude Sweep with RF Monitor**

Amplitude sweep will generate single tone sine wave with constant frequency and phase and linear amplitude increase starting from start amplitude and ending at stop amplitude.

RF monitor with input at CH1 will measure RF level and display magnitude.

One example application would be amplifier linearity, gain, input and output amplitude range.

1. Select “Amplitude Sweep” in “Mode” combo box
2. Enter frequency
3. Enter start and stop amplitude
4. Click “RUN” or “REFRESH”

## **Digital Sampling Oscilloscope (DSO)**

The Digital Sampling Oscilloscope provides two high speed channels with an analog bandwidth of 10 MHz for any signal source and 100 MHz for signals synchronized from same device generator.

Two different kinds of ADC converters are provided.

One 2 channel ADC with maximum 40Ms/s and with 8 bit resolution and second one with one channel, 480Ks/s 12 bit resolution allowing higher dynamic range for low frequency signal such as audio.

Two sampling modes are available, real time and interleaved under sampling.

Real time sampling is provided for signals up to 10MHz and (time base 1s - 100ns)

**For signal sourced from the DDSG2A Function Generator (and with allowable frequency shift of 1 kHz), interleaved under sampling mode extends the signal measurement capability to up to 100 MHz (time base: 1us - 1ns)**

The DSO is configured and its result displayed via the “DDSG2A Monitor Window” which is part of DDSG2A Application.

DDSG Monitor Provides an easy to use graphical interface for oscilloscope, frequency and amplitude sweep functions and the frequency counter.

Graphical results for DSO and sweep functions are displayed at resolution of 640x512 pixels.

In oscilloscope mode, the display provides a view of the most recently acquired samples (mapped onto 640 pixels)

In addition, the monitor applications records 2048 mapped samples so that scope display window can be moved back in time to view previously captured signals (just over 3 windows). Cursor measurements functions are provided for both horizontal and vertical quantities. Trigger amplitude and CH1/CH2 zero levels are displayed visibly in monitor window and can be controlled by user.

### DSO Specifications:

Parameter	Min	Max	Typical	Description Comments
Real Time Scope sampling speed	64 S/s	2x40MS/s 8bit 1x500kS/s 2 bit		
Real Time Scope Bandwidth	DC	10Mhz		Vertical amplifier bandwidth is 100 MHz but sampling speed limits usable bandwidth to 10Mhz
Scope Record length	640	2048		
Scope Input Impedance			1Mohm/20pF	
Scope Display Size			640 X 512	
Scope Vertical display divisions	10mV, 20mV, 50mV, 100mV, 200mV, 0.5V, 1V			10mV works only in 12 bit mode
Real time Horizontal/div:	100n, 200n, 500n, 1u ,2u ,5u, 10u, 20u, 50us, 100u, 200u, 500, 1m, 2m, 5m, 10m, 20m, 50m, 100m, 500m, 1s			
Interleaved under sampling mode Horizontal/div	1n, 2n, 5n, 10n, 20, 50n, 100n, 200n, 500n			
Oscilloscope Interleaved under sampling mode bandwidth	1Mhz	100Mhz		<b>Works only if signal originated from same generator or is synchronized from same generator and frequency is allowed to shift up to 1kHz</b>
Frequency counter frequency range	1Hz	1GHz		Prescaler used is rated 2GHz, but device is tested with 1Ghz

Frequency counter max input voltage			5Vpp	This can be extended with scope probes for frequencies 1Hz-20MHz
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### **Using Real Time Oscilloscope**

Real time oscilloscope can work as one channel 500Ks/s 12 bit or two channels with maximum speed of 40 Ms/s simultaneously on both channels

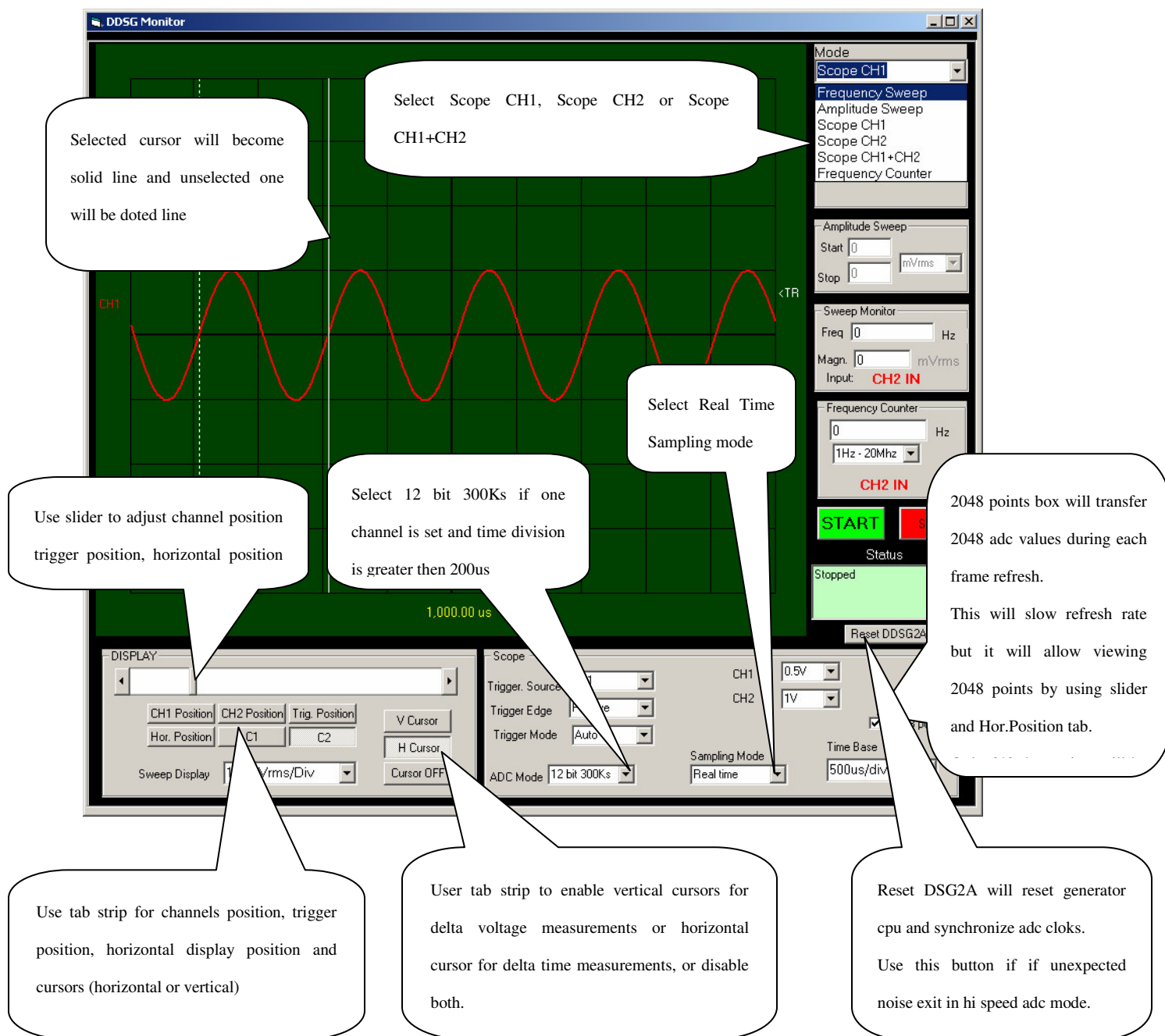
Fastest time division in 12 bit mode is 200us and 100ns in 40Ms/s mode

It is recommended to stop display before changing any settings or moving channels, trigger, and cursor position.

If stop button is not used then process will be too slow.

For best results use standard oscilloscope passive probes with division ratio of 10 and bandwidth of 100 MHz or higher and calibrate probes input capacitance for best results

Generator in “Square Wave” mode with 1kHz output can be used for passive probes input adjustment.



## Using FFT Spectrum Analyzer

FFT spectrum analyzer can be used in CH1 only or CH2 only mode.

2048 samples box have to be checked before scope start.

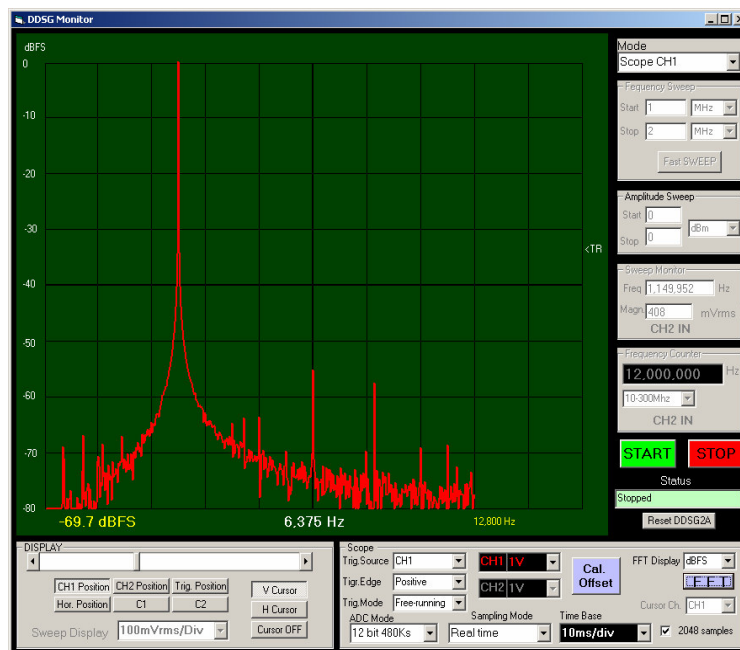
Select time base so that frequency of interest is covered with at least 10 or more periods.

Select volt dive so that amplitude covers between half and  $\frac{3}{4}$  of vertical display.

Use 12 bit ADC if frequency is low like in audio range for greater dynamic range.

Click “RUN” to display waveform as scope and fill buffer.

Click “STOP” and then “FFT” button.



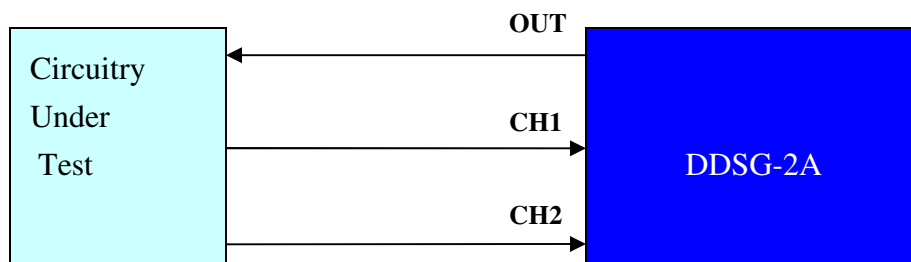
Picture on right shows 1 kHz 5Vpp sine wave generated with same device generator using 12 bit ADC.

Moving mouse over display will update frequency and magnitude information found at the bottom of screen.

## Using Interleaved Under-Sampling Oscilloscope

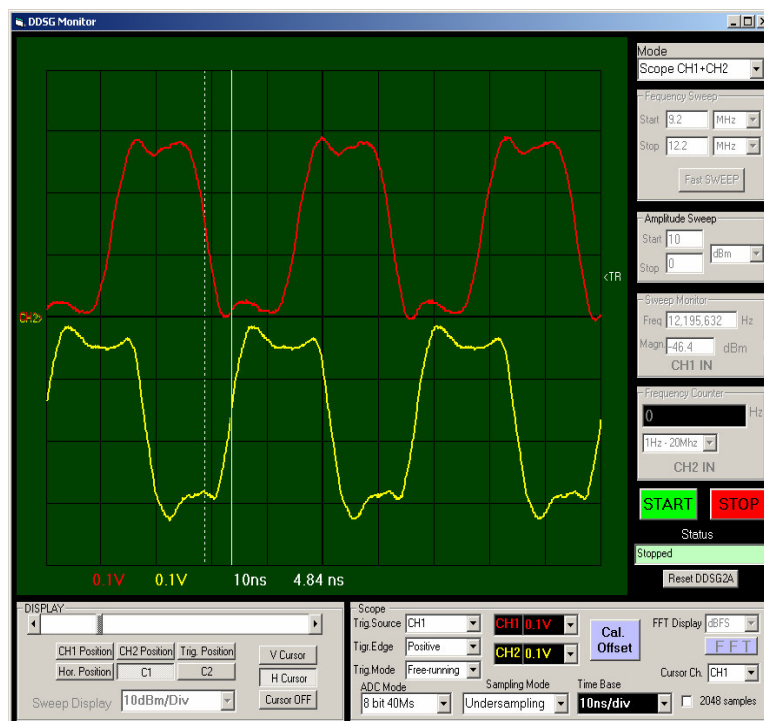
Interleaved sampling mode allows hi resolution timing measurements by using synchronizing signal source (generator) with scope and by controlling sampling phase.

This mode can not work properly if signal did not originate from same generator or is synchronized with it as shown on diagram below.





Picture shows propagation delay test of logic NOR gate 74AC00 with generator with "Square Wave2" mode 30mhz 3.3v output amplitude connected with short not terminated coax 50 cable to input gate and passive probes 200mhz bandwidth x10 converted at gate input@ CH1 and output@CH2)



## Using Frequency Counter

Frequency counter have 3 frequency ranges.

Range 1 Hz-20 MHz uses scope channel one (CH1 IN) input amplifier to allow dc coupling for low frequency counting and amplitude adjustment.

Range 10-300 MHz and range 200-2000 MHz uses presales and are ac coupled with input impedance of 50 ohm. And it requires 50 ohm coax cable connection.

## Calibration

Device is calibrated by adjusting calibration data in calibration file which is unique for each device. Calibration is done after device is produced and user can calibrate it using previously calibrated instruments like oscilloscopes, millimeters, frequency counters...etc.

"CaldataXXXXXXXX" text files contains calibration data loaded at software start up and if manually loaded thru Calibration File load Button.

"XXXXXXXX" Portion of calibration data file name represent device serial number found on device label and stored in device USB chip.

This allows multiple DDSG2A devices to be used with same PC with multiple application open.

Changing Cal Data values will affect generator frequency, DC offset, Amplitude, oscilloscopes voltage accuracy ...etc

**Generator Frequency** is calibrated by fine tuning calibration data in line 2 of cal data file. This line is initially 1 since TCXO have 2.5ppm accuracy which is best we have available. Increasing values will increase frequency.

**Generator Sine Wave Amplitude** in frequency range:

Increasing values of cal data will increase amplitude.

DC-1Mhz is done with adjusting line 4

10 MHz - adjust cal data line 5

20 MHz - adjust cal data line 41

30 MHz - adjust cal data line 42

40 MHz - adjust cal data line 43

50 MHz - adjust cal data line 6

60 MHz - adjust cal data line 44

70 MHz - adjust cal data line 45

80 MHz - adjust cal data line 46

90 MHz - adjust cal data line 47

100 MHz - adjust cal data line 7

**Generator Square Wave2 amplitude** is calibrated by fine tuning calibration data in line 28 for 1Vpp

Increasing values in cal data will decrease amplitude.

1Vpp – line 28

2Vpp – line 29

3Vpp – line 30

4Vpp – line 31

5Vpp – line 32

**Generator DC Offset** for sine waves and square wave is calibrated by fine tuning calibration data in line 3 of cal data file. Increasing values of cal data will increase offset voltage.

**Generator Arbitrary Voltage DC offset** is calibrated by fine tuning calibration data in line 11

Increasing values of cal data will increase offset voltage.

**Generator Ramp DC offset** is calibrated by fine tuning calibration data in line 13

Increasing values of cal data will increase offset voltage.

**RF Voltage detector(log amp) Offset (intercept)** is calibrated by fine tuning calibration data in line 15

Increasing values of cal data will increase RF detector offset.

**Oscilloscope CH1 Gain for 1V/div and 0.5V/div** is calibrated by fine tuning cal data line 19

Increasing values of cal data will decrease scope voltage gain

**Oscilloscope CH1 Gain for 0.2V/div and 0.1V/div** is calibrated by fine tuning cal data line 18

**Oscilloscope CH1 Gain for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 35

**Oscilloscope CH2 Gain for 1V/div and 0.5V/div** is calibrated by fine tuning cal data line 24

**Oscilloscope CH2 Gain for 0.2V/div and 0.1V/div** is calibrated by fine tuning cal data line 25

**Oscilloscope CH2 Gain for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 38

Scope offset cal data is used only at device application start up before “Cal Offset” Button is activated. “Call Offset” button is used to set dc offset to zero when scope probes are open or connected short to ground.

**Oscilloscope CH1 Offset for 1V/div,0.5V/div,0.2V/div,0.1V/div** is calibrated by tuning cal data line 21

Increasing values of cal data will decrease scope voltage gain

**Oscilloscope CH1 Offset for 50mV/div and 20mV/div** is calibrated by tuning cal data line 34

**Oscilloscope CH2 Offset for 1V/div,0.5V/div,0.2V/div,0.1V/div** is calibrated by tuning cal data line 26

**Oscilloscope CH2 Offset for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 37